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Natural Gas Dehydration Process Simulation and Optimization: a Case study of Khurmala Field in Iraqi Kurdistan Region

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ABSTRACT

Natural gas is the most important & popular fossil fuel in the current era and future as well. Raw natural gas exists in deep underground reservoirs under certain temperature & pressure. Therefore, it may content several of non-hydrocarbon components for example, hydrogen sulphide, nitrogen and water vapour. In order to meet gas sale contract specifications, these impurities should be removed or reduced. Indeed, non- hydrocarbons components usually cause several technical problems for example, corrosion and environment pollution. Khurmala dome is located in southwest Erbil-Kurdistan region. The Kurdistan region government has paid great attention for this dome to provide the fuel for Kurdistan region. However, the Khurmala associated natural gas is currently flaring at the field. Khurmala gas could be recovered and utilized either as feedstock to power station or to sell it in global market. However, the laboratory analysis has showed that the Khurmala sour gas has huge quantities of H_2S about (5.3%) and CO2 about (4.4%). Indeed, Khurmala gas sweetening process has been achieved in previous study by using Aspen HYSYS. However, Khurmala sweet gas still contents some quintets of water about 23 ppm. This amount of water vapour should be removed or reduced. Indeed, water contents in natural gas cause several technical problems for example, hydrates and corrosion. Therefore, this study aims to simulate the prospective Khurmala gas dehydration process by using Aspen HYSYS program. Moreover, the simulation process succeeds in reducing the water content to less than 0.1 ppm. In addition, the simulation work is also achieved process optimization to find out the most effective glycol type to remove the water vapour from natural gas stream by adopting several desiccant types for example, TEG and DEG.

Keywords: *Natural gas dehydration, Khurmal dome, glycol, process simulation, Aspen Hysys, process optimisation.*

Some nomenclature

H_2S	Hydrogen sulfide	MEA	Monoethylene glycol
CO_2	Carbon dioxide	DEG	Dimethyl Glycol

1. INTRODUCTION

The demand for natural gas in recent decade has been dramatic. Natural gas poses a huge rule in the recent world economy and development. However, natural gas is existed in deep underground reservoir under certain temperature and pressure. Therefore, it may content several of no hydrocarbon components for instance, carbon dioxide, nitrogen and water vapour. Indeed, natural gas to be transported by gas pipelines or processed should meet certain specifications for example, H_2S must be reduced to less than 4 ppm [1]. Indeed, Khurmala dome is the northern most domes of the Kirkuk oil fields structure. Moreover, the dome is located approximately 20 kilometers by 8 kilometers. However, the dome has not developed until 2003. Nowadays Khurmala field is considered as main fuel source for Iraqi Kurdistan region KAR [2]. In fact, Khurmala associated natural gas is currently flared at the field. There is a plan to recover and traded this gas to use it either as feedstock to power station or to sell it in global market. However, the laboratory analysis has showed that the Khurmala natural gas has huge quantities of H_2S about (5.3%) and CO_2 about (4.4%) [3]. Khurmala sweetening process has been done in previous study by using Aspen Hysys. However, Khurmala sweet gas still wet and content considerable amounts of water vapour which it may lead to several technical problems such as, hydrate formation and corrosion. Indeed, water vapour in natural gas should be reduced or removed and the main reasons for removing of water from natural could be summarized as following: Water content of natural gas decreases of its heat value, liquid water in natural gas pipelines potentially causes slugging flow conditions resulting in lower flow efficiency of the pipelines [4]. In most commercial hydrocarbon processes, the presence of water may cause side reactions, foaming or catalyst deactivation. Therefore, to prevent such problems, natural gas treating is unavoidable. There are different methods for water treating of natural gas for example, adsorption, absorption, membrane process, methanol process and refrigeration [5]. Among mentioned methods absorption, which is called dehydration and use liquid solvent as an absorbent, is mostly common technique for treating of natural gas [4-5]. Indeed, gas dehydration by glycol is capable to reduce the water content of natural gas less than 0.1 ppm [6].

2. GAS DEHYDRATION PROCESS DESCRIPTION

Glycol process is considered the most successful and common process in gas industry field [4]. Indeed, this process is utilized glycol liquid desiccant as a chemical solvent to remove water vapour from natural gas stream. Moreover, glycol liquid has high affinity toward water vapour and there are several types of glycol that are used in glycol process for example, monoethylene Glycol MEG and dimethyl Glycol DEG [4]. Dehydration process is consisting of several operation units for instance, contactor tower, regenerator tower and heat exchanger. Figure (1) shows typical gas dehydration process. During the process, lean glycol such as DEG enter to the absorption column at the top side which rich solvent is collected at the bottom of the column and will send to the regenerator [7]. Wet gas enters to the absorption column after passed through inlet scrubber. The scrubber removes free liquid and liquid droplets in the gas, both water and hydrocarbons (removing liquid in the scrubber decrease the amount of water that has to remove in the absorption column, and this also decrease the size of the column and therefore decrease the TEG needed in process) [6-7]. Heat exchanger uses for cooling of wet gas before enter to scrubber. Rich TEG passes through a coil, which is used as reflux at the top of the absorption column; to increase its temperature. A tree phase flash tank uses for removal of absorbed acidic gases and hydrocarbons in TEG before rich solvent enter to the regenerator, which is a distillation column, and separate the TEG and water content. Indeed, rich TEG is preheated in another heat exchanger before it fed to the regeneration section. At the end of the process cycle, the regenerated TEG will cool in the third step of heat exchanger and will back to the dehydration column for reuse [8].

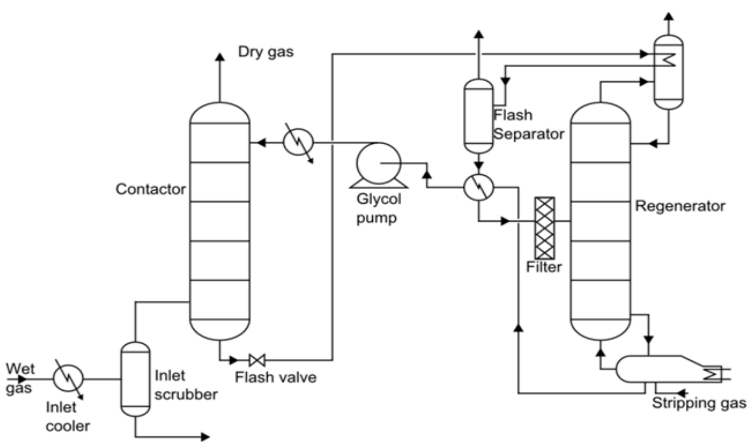

Figure1: Typical gas dehydration process.

3. KHURMALA WET GAS COMPOSITION

As mentioned earlier, the Khurmala gas sweetening has been achieved in previous study [3]. The Khurmala sweet gas stream composition and operating conditions that achieved by HYSYS simulator are shown in table (1).

Table (1) Khurmala raw natural gas composition & operation conditions.

Components	Mole %
Methane	0.7164
Ethane	0.1565
Propane	0.0606
i-Butane	0.0153
n-Butane	0.0276
i-Pentane	0.0114
n-Pentane	0.0083
n-Hexane	0.0013
Water	0.0023
Carbon dioxide	0.00004
Nitrogen	Trace
Hydrogen sulfide	Trace
Operation condition	
Pressure	3555 K.pa
Temperature	40 °C
Flow rate	250MMSCFD

4. STEADY STATE SIMULATION AND OPTIMISATION

The expected Khurmala gas dehydration plant is simulated by using Aspen HYSY. The TEG is utilized as an aqueous absorbent to absorb water vapour from wet gas stream. The first step of simulation could be done by adding the gas stream compositions and conditions which it same data of this case study. Moreover, Hysys fluid package should be carefully chosen which it should be (Glycol Pkg) as shown in figure (2).

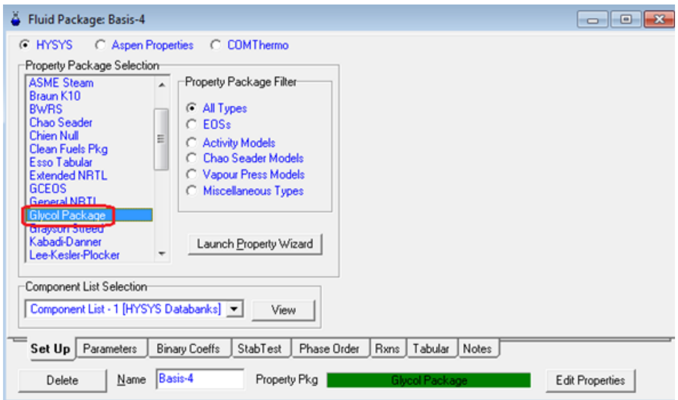

Figure 2: Hysys fluid package menu

After achieving above step, the simulation environment is entered. Moreover, simulation environment may consider the main simulation area, which it deals with the plant and shows the FPD for the process. It important to uses inlet gas separator to remove any undesirable impurities such as, solid particulars and liquids. Glycol contactor tower is also important part from the plant which it also need some specifications for example, streams temperature and pressure and the TEG concentration (99% is used) and figure (3) shows Glycol contactor menu. Moreover, rich glycol needs to be regenerate and that could be achieved by installing the glycol regenerator and figure (4) shows glycol regenerator menu. Khurmala gas composition and water content calculations.

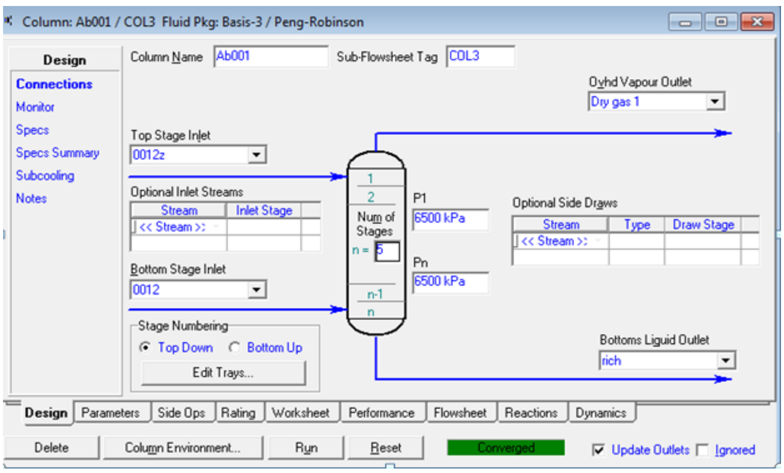

Figure 3: Glycol contactor menu.

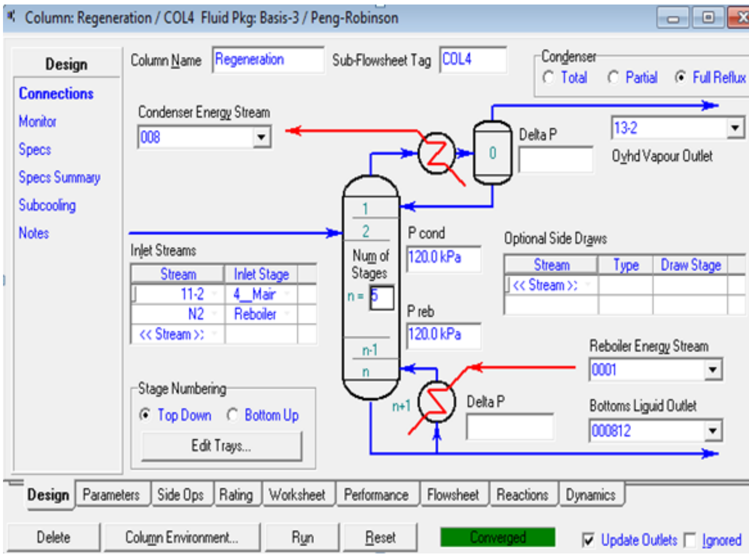

Figure 4: Amine regenerator menu.

The simulation process done successfully and figure (5) shows process flow diagram of Khurmala gas dehydration plant. As it seems from fig. 5 several process unites are used in glycol process. Infect, installing flash separator for rich glycol is quite important in order to avoid any technical problems. In addition, water make up stream should be added with a mixer to the process. Infect, glycol concentration may be built up in the process because of water and amine losses with dry gas. Therefore, water makes up stream will maintain and support the concentration of TEG at acceptable value. The simulation process done and the process achieved high water removal that it will be discussed in result and discussion part. To make up the lost TEG the gas stream from the contactor, separator and regenerator is entered into a component splitter. In the component splitter the TEG is separated from the gas, creating a stream of pure TEG that is transferred back to the TEG stream. A mixer is required to mix the recovered TEG with the TEG from the regenerator and figure (6) shows splitter element menu.

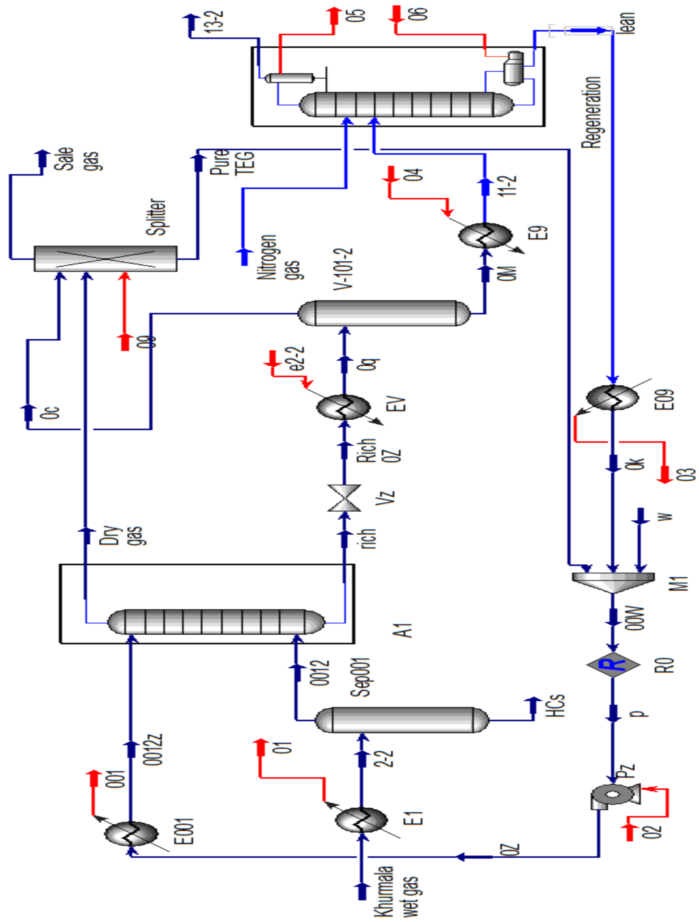

Figure (5): Process flow diagram of Khurmala gas dehydration plant.

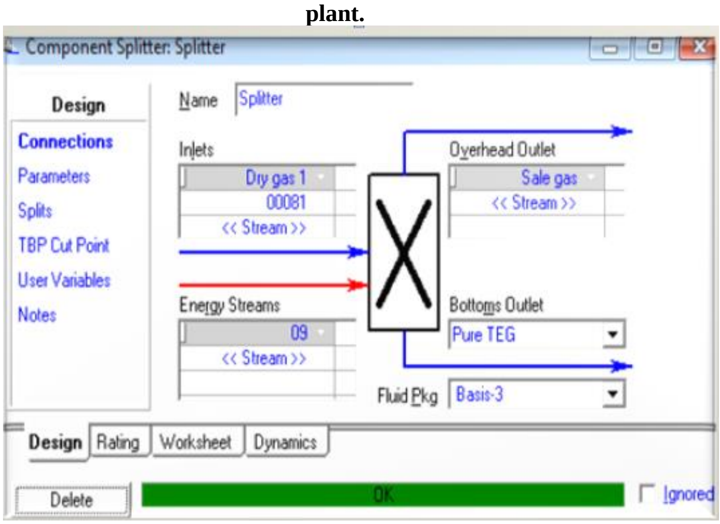

Figure 6: Glycol splitter menu

The TEG from the regenerator is cooled and recycled back to the TEG inlet stream. To do this a logical recycle operator must be inserted between the two streams. There is a problem with the recycling of the TEG; this is that small amounts of TEG are lost from the system in the gas flow from the contactor, separator and regenerator. The lost TEG must be replaced, or less TEG than required is recycled to make up the lost TEG the gas stream from the contactor, separator and regenerator is entered into a component splitter. In the component splitter the TEG is separated from the gas, creating a stream of pure TEG that is transferred back to the TEG stream. A mixer is required to mix the recovered TEG with the TEG from the regenerator. Nitrogen The glycol regenerator has five trays and provided with a condenser and a boiler. The rich glycol enters the regenerator on the middle tray. Glycol purities up to 99.9 wt% can be achieved by using stripping gas from the top of the stripping column. The stripping gas is usually nitrogen [9]. The water can be removed from the stripping gas by cooling it well below waters dew-point. Process optimization is also achieved and the aim of this optimization work to examine several specific operation conditions such as absorbents circulation rate on the process efficiency.

5. RESULTS & DISCUSSION

Khurmala gas dehydration plant is achieved by Aspen Hysys simulator and TEG is adopted firstly as absorbent liquid and it achieved good dehydration result at moderate circulation rate. However, process optimization is also carried out to find the most appropriate absorbent and circulation rate.

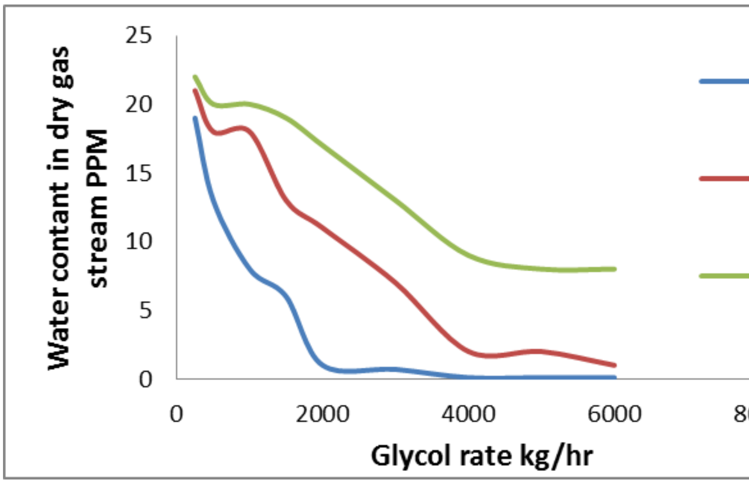

Figure 7: Water content in the dehydrated gas for the different absorbents.

From figure (7) it could be seen that the dehydration efficiency of the different glycol types are vary. MEG needs high flow rates of absorbent to obtain low water removal from the gas, and the lowest concentration possible is as high as about 7 ppm and water removal reach equilibrium at about 4500 kg/hr glycol circulation rate. However, DEG and TEG can remove huge quintets of water at low absorbent circulation rate. TEG achieved ideal water removal at 4000 kg/hr which about 0.1 ppm and then it reached equilibrium state.

6. CONCLUSION & RECOMMENDATION

In conclusion, this study is achieved Khurmala gas dehydration process simulation and optimization by using Aspen HYSYS. It can argue that Khurmala wet gas content some quintets of water vapour which may lead to sever technical problems for instance, hydrate formation and pipeline corrosion. However, this problem could be solved by designing & installing gas dehydration unit for khurmala gas plant. Moreover, simulation work achieved high water removal. It could be argued that using TEG glycol at 4000 kg/hr circulation rate can achieve excellent drying results. However, the adopting of high TEG circulation rate may lead to increase the process operation cost & TEG losses as well. Therefore, the using of TEG circulation rate about 2000 Kg/hr could archive acceptable drying results.

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